

INSTRUCTION MANUAL
MODEL 103, 103R
AMPLIFIER
AND 1031, 1031R POWER SUPPLY

CALLAB



KEITHLEY INSTRUMENTS



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WARRANTY

We warrant each of our products to be free from defects in material and workmanship. Our obligation under this warranty is to repair or replace any instrument or part thereof, except tubes, transistors, fuses, and batteries, which, within a year after shipment to the original buyer, proves defective on examination.

DAMAGE IN SHIPMENT

Be sure to include the instrument model number and serial number in all communications.

If the instrument is damaged when received, or fails to operate properly, a claim should be filed with the carrier. Upon receipt of the claim agent's report, we will inform you regarding repair or replacement.

REPAIRS

When returning an instrument for repair or recalibration, it should be securely packed against shipping damage and sent to the factory, freight prepaid. A brief letter describing the difficulty should accompany the instrument.

SECTION I - INTRODUCTION

The Keithley Model 103 Amplifier is an ultra-low noise preamplifier with a bandwidth of 0.1 cycles to 100 kc and gains of 100 and 1000.

The Model 103 amplifier features a "normal" and "low noise" switch. In the normal position the input impedance is 10 megohms. In the low noise position it is 100 K. However, the "low noise" position has an input noise almost one half of the noise on the normal position.

The Model 103 is of use wherever low-level ac signals within its bandwidth are to be amplified. It also offers high and low frequency filters to reduce the effective bandwidth and improve the signal to noise ratio.

The Model 103 may be used either single-ended or as a differential amplifier. Its output is sufficient to drive oscilloscopes or pen amplifiers. It is not intended to supply output power.

Batteries or the Model 1031 power supply may be used to power the amplifier. A unique feature of the 1031 power supply is that the operation is completely equivalent to battery operation provided that the power supply is kept a small distance (usually about 12 inches) from the amplifier to eliminate stray pick-up from the transformer fields. In either mode of operation, however, the 103 is characterized by extremely low noise, absence of "bounce" and very low microphonic output.

Flicker noise is much reduced over previous design of this type through the use of ceramic input tubes.

SECTION II - SPECIFICATIONS

NOISE: Input shorted, 10 cps to indicated cutoff, gain 1000 x

Frequency of high cutoff point	Maximum noise, microvolts rms referred to input	
	Normal	Low Noise
100 kc	3.0	1.9
30 kc	1.9	1.1
10 kc	1.4	.8
3 kc	0.9	.6
1 kc	0.7	.4
300 ~~kc~~ cps	.5	.3
100 ~~kc~~ cps	.4	.25

At frequencies below 10 cps, tube flicker noise will add approximately 1 to 4 microvolts RMS noise to the above figures, depending on the cut settings. Noise at input resistances higher than shorted depends on the effective source impedance. The source noise adds in quadrature to the specified input noise.

FREQUENCY RESPONSE:

"Normal" Position: Bandwidth is at least 0.1 cps to 100 kc (3db points). High Frequency Cutoffs: Seven, (20 db/decade) with 3 db points at 100 kc, 30 kc, 10 kc, 3 kc, 1 kc, 300 and 100 cps.

Low Frequency Cutoffs: Four, at 0.1, 1, 10, and 100 cps. High and low cutoffs selected by separate switches.

Accuracy of the 3 db points is $\pm 20\%$ of frequency except the response is at least 0.1 cps and 100 kc at full band on normal position.

"Low Noise" Position: High frequency response and cutoffs are the same. Low frequency response may be varied between 7, 10, and 100 cps only.

GAIN: Either 100 or 1000, selectable from the front panel. Gain may be calibrated by means of a screw driver adjustment. The gain will increase approximately 2:1 from the normal to the low noise position, but can be recalibrated by the gain adjust control.

REJECTION RATIO: Adjustable to greater than 80 db at midband on normal position; 60 db at midband on low noise position.

MAXIMUM INPUT SIGNAL: 20 millivolts peak-to-peak at a gain of 1000 and 200 millivolts peak-to-peak at a gain of 100.

INPUT IMPEDANCE: Normal: 10 megs, 20 mmf, either input to ground. Low Noise: At least 100 k, 20 mmf either input to ground.

INPUT: Single ended or differential.

OUTPUT: Maximum output, 20 volts peak-to-peak into 100 k, 100 mmf. Higher loading will decrease the frequency response and output. Output impedance is approximately 2000 ohms.

TUBE COMPLEMENT: 4-7586, 2-EF86, 1-12AU7.

POWER REQUIREMENTS: 12 volts at 780 ma, +135 volts at 6 ma, and -90 volts at 6 ma. The 103 may be powered either by the 1031 Power Supply, specified below, or by batteries. The power supply or batteries must be purchased separately.

ACCESSORIES SUPPLIED: Power connector and 10-foot cable designed to operate with a 12-volt storage battery and five 45 volt "B" batteries. Mating input and output connectors.

ACCESSORIES AVAILABLE: Model 1031 Power Supply.

DIMENSIONS, WEIGHT: 5 1/8" wide x 7 1/2" high x 11 1/4" deep. Net weight 9 lbs.

MODEL 1031 POWER SUPPLY:

VOLTAGES: As required for Model 103 amplifier

REGULATION: Equivalent to battery operation for the line voltage stated below.

POWER REQUIREMENT: 105 to 125 or 210 to 250 volts 50/60 cps. Power consumption approximately 40 watts.

TRANSISTOR COMPLEMENT: 1-2N1535, 3-2N1183, 4-2N1381.

ACCESSORIES SUPPLIED: Connector cable to 103 amplifier

DIMENSIONS, WEIGHT: 5 1/8" wide x 7 1/2" high x 11 1/4" deep. Net weight 5 lbs.

A. OPERATING CONTROLS:

The operating controls are all located on the front panel. Their function is as follows:

1. Power Switch: The power switch turns the power on and off only when operating with batteries. If the amplifier is being operated with the Model 1031 Power Supply, the power switch on the panel of the power supply is used to turn the instrument on and off. The pilot light is so wired that it will correctly indicate if the instrument is on either with batteries or with power supply.
2. Gain: The gain is selectable, as indicated, at either 100 x or 1000 x.
3. High Cut: As indicated on the panel, the high frequency 3 db point may be selected as desired. The roll-off is at the 20 db/decade.
4. Low Cut: As indicated the low frequency 3 db point can also be selected. The roll-off is also 20 db/decade.
5. Gain Adjust: This control is used to adjust the gain to the exact value.
6. DC Level: This control is used to adjust the dc level of the output signal to zero when using a direct-coupled oscilloscope or pen amplifier following the preamplifier.
7. Normal - Low Noise Switch: In the normal position, the 103 is a high impedance amplifier with excellent noise figure. However, in the low noise position the bias is changed on the input tube. This results in low input impedance but an improvement of about 50% in the noise figure. Both the low frequency response and the gain are changed by this switch.

B. PRELIMINARY SET-UP:

1. For single ended input, ground one grid and use the other for the signal. If desired, the polarity of the output signal may be reversed by using the second grid.
2. For differential input use both grids and balance signal to ground.
3. The object or the source being measured should be carefully shielded to avoid stray pick-up.
4. If the 1031 power supply is used keep it well away from the input circuits.
5. Connect a suitable oscilloscope or other indicating device

to the output. If the indicating device is direct-coupled, adjust the output level control to allow the output indicator to balance. If it is desired to use very high gain after the amplifier it may not be practical to employ direct coupling. If frequency response below 10 cps is not desired, the "AC position on oscilloscopes and pen writers may be used to prevent variations in the dc level of the amplifier from causing trouble. If lower frequency pass-band is desired, a 10 or 20 mfd capacitor may be used to couple the output of the 103 amplifier to the dc terminals of the indicating device.

C. POWER SUPPLY:

Connect the amplifier to batteries as indicated in DR14610B at the rear of the manual, or use the Model 1031 power supply:

1. Battery Operations: Battery operation requires a 12 volt lead storage battery and five 45 volt B batteries. The types of batteries are not critical as long as they have sufficient capacity to yield a reasonable operating life. Burgess type 5306 or Eveready type 7628 are recommended for the B batteries and are connected in series to give plus 135 and minus 90 volts. The 12 volt battery can be any make of automobile or motorcycle lead storage battery. A battery charger and hydrometer should be used to keep the storage battery in good condition. The storage battery should not be charged during operation of the amplifier since this will cause 60 or 120 cps output ripple.

It should be realized that the gain of the amplifier will decrease as the batteries run down. It will, therefore, be necessary to check the gain fairly often on battery operation.

2. Power Supply Operation: The Model 1031 power supply is completely self-contained and requires no maintenance. Connect the amplifier to the power supply with the cable provided. Be sure that the power supply is at least twelve inches from the amplifier. In rack-mounted units, the best results are obtained if the amplifier and power supply are not mounted directly along side. However, in the standard three-unit rack frame supplied, in most cases satisfactory performance will be obtained if the amplifier is mounted to one side of the frame and the power supply to the other and the middle section left empty.

D. GAIN CHECK:

To check the gain, the calibrator present on the front panel of most oscilloscopes can be used. The gain may be checked and adjusted on either the 100 x or 1000 x steps and the other gain step will be also accurately adjusted. With power supply operation, the gain will be stable to 2 or 3 percent for long periods, however, with batteries the gain will vary as the batteries run down and, therefore, should be checked more often. When checking gain do not use more than a 20 millivolt signal on the 1000 x gain and more than a 100 millivolt signal on the 100 x gain step.

E. AMPLIFYING AC SIGNALS:

1. Effect of Input Impedance: The input impedance of the instrument at the input terminals is 10 megohms or 100 k shunted by 20 mmf depending on operating mode selected. The actual input impedance, particularly the capacitive portion will depend on the length of cable employed at the input. In many cases this is not critical, however, if the internal impedance of the source is at all high it will pay to bring the amplifier as close to the source as possible and to use the shortest length of cable feasible if full frequency response is desired. Also, at high impedances noise due to cable flexure will become apparent.

2. Choice of Operating Range: The Model 103 offers either a ten megohm input impedance "normal range" or a 100 k input impedance "low noise range". On the lower noise range, the noise is 30% to 50% less than the normal range over an equivalent bandwidth. If the impedance of the source is not over 10,000 ohms, probably the low noise range will give a better signal to noise ratio. If the source impedance is high, however, little advantage is obtained from the low impedance range. This is so because the noise generated by the source impedance will be much greater than the input noise on the "normal range". Thus, the reduction of the input signal due to circuit loading on the low noise range will over balance the noise reduction. In either case the gain and in-phase rejection must be adjusted when changing from the "normal" to the "low noise range".

3. Input Noise: The noise specifications given for the Model 103 are for noise referred to the input. This is to say, the noise that appears at the input terminals or the noise at the output terminals divided by the amplifier gain. For example, a noise figure of 3 microvolts rms referred to the input means, that if the amplifier has a gain of 1000 that the output noise will be 3 millivolts rms. As can be gathered from the specifications, the noise will vary with input impedance and bandwidth. In general the peak-to-peak value of the noise will be approximately five times the rms value.

a. Sources of Noise in an AC Amplifier: The sources of noise may be enumerated below:

1. Tube Noise: Under tube noise may be grouped shot noise, flicker noise, grid current noise, and microphonics. The ceramic tubes used in the input have been chosen for their low microphonics, low flicker noise, and low grid current. The cascode circuit together with the tubes used yields low shot noise. The flicker noise will predominate at frequencies below about 100 cps while the shot noise will be greater at higher frequencies. Therefore, judicious use of the high and low frequency cut-offs will enable the user to eliminate a large amount of noise by restricting the bandwidth just to the desired frequencies. The tube noise represents the irreducible measurement threshold.

2. Johnson Noise: The noise appearing at the input above the tube noise is due to thermal agitation noise in the impedance across the input.* The mean square noise is given by:

$$v^2 = 4kTR \, df \quad (1)$$

where v is the noise voltage; k is Boltzmann's constant, 1.37×10^{-23} joules/°K; T is the absolute temperature; and R is the resistance of the input circuit (including the source) in ohms.

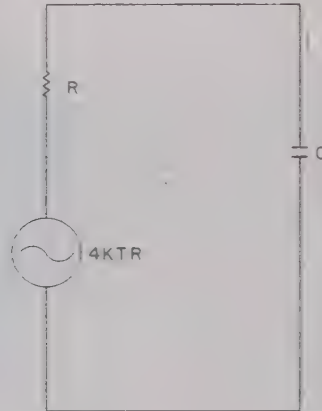


FIG 1

Since the input circuit may be represented as in a zero impedance voltage generator in series with a noise-less resistor (Fig. 1), R , and the input capacitance, C , shunting the resistance, the following expression represents the noise in the input circuit with a given R and C :

$$v^2 = \int_{f_1}^{f_2} \frac{dt}{1 + (\omega CR)^2} \quad (2)$$

where f_1 and f_2 are with sufficient accuracy the lower and upper 3 db points of the bandwidth. Performing the integration, the expression is:

$$v^2 = \frac{4 k T}{2\pi C} \left[\tan^{-1} 2\pi f RC \right]_{f_1}^{f_2} \quad (3)$$

To use the expression, substitute the values indicated and solve the resulting algebraic expression. The total noise should be:

$$V_t = (V_a^2 + V_b^2)^{\frac{1}{2}}$$

where V_t is the total noise, V_a is the Johnson noise and V_b is the amplifier noise.

In summary, the total noise is due in part to the tube noise and is also proportional to the square root of the bandwidth and input impedance.

*For a complete discussion of the noise problem see "Signal Noise and Resolution in Nuclear Counter Amplifiers", by A. B. Gillespie, McGrawhill Book Co., 1953.

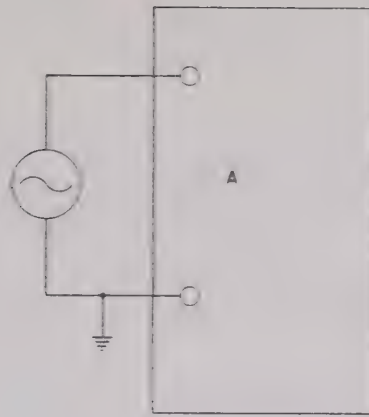


FIG 2A

3. Single Ended and Differential Input: Single ended input is accomplished by grounding one grid and using the other for the signal as shown in Fig. 2A. This is the simplest configuration, one terminal at ground and the other the signal lead. The ground terminal of the source must be firmly grounded to the ground of the amplifier. This configuration, however, offers no discrimination against spurious signals.

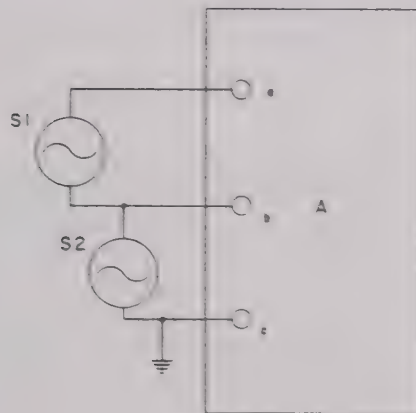


FIG 2B

With the differential input as shown in Fig. 2B, the amplifier is a three terminal affair. If the input to a and b is the same, the output of the amplifier will be less than 1/1000 of the signal which would be present if the signal is applied either input to c. Therefore, if in Fig. 2B S1 represents the wanted signal and S2 a spurious signal, the amplifier will strongly discriminate against S2. This system may be used in many cases where it is desired to eliminate interfering signals.

SECTION IV - CIRCUIT DESCRIPTION

A. AMPLIFIER:

(Refer to DR14464D) The amplifier consists of a balanced cascode input stage V1 through V4, followed by a differential pentode amplifier V5 and V6 and an output cathode-follower, V7.

The input stage achieves very low noise through the use of the cascode configuration, shock mounting and ceramic tubes in the input. Potentiometer, R106, adjusts one grid of the cascode circuit to set in-phase rejection. The coupling from the first stage to the second is through selectable capacitors C105 through C112. By selecting the coupling capacitor the low frequency response is varied as indicated. An attenuator composed of R111 through R114, selects either a gain of 100 or 1000. V5 and V6 form a conventional balanced amplifier. R116, a 10 k potentiometer, shunts R117 and R119 to adjust the gain. A 50 k potentiometer R118 adjusts the plate potential of V5 and V6. Since output tube V7a is direct coupled via R127 and R128 to V5, this adjustment is sufficient to adjust the dc component of the output signal to zero. V7b's cathode is not brought to an output terminal. The purpose of V7b is to balance the load on the power supply. C122 to C127 are shunted across the plates of V5 and V6 to allow variation in the high frequency cut-off.

SW5 switches R135 across ¹⁰³R104 to change the bias of the input stage. This causes V1, V2, V3, and V4 to operate at lower bias, decreases the input impedance and lowers the input noise.

B. MODEL 1031 POWER SUPPLY:

(Refer to DR14440 D) The Model 1031 power supply consists of an ultra-stable transistor regulator which supplies 12 volts at 1.2 amperes. The regulation of this power supply is better than 0.005% for a line voltage variation of 100 to 130 volts. The output is used directly to light the filaments of the amplifier. A portion of the 12 volt power is converted to the B plus and B minus voltages by means of a transistor switch and a step-up transformer. The stability of these voltages is essentially that of the 12 volt regulated supply. Therefore, very close line regulation is provided for all voltages with great economy.

In detail the circuit description is as follows:

T1, is a 50/60 cps transformer operating from the power line. Its secondaries and D1 through D3 supply a dc of 18 volts at 1.2 amperes and 117 volts at 5 ma. These supplies are filtered in the conventional way. The 18 volts is regulated by means of a regulator consisting of transistors Q1 through Q6 to provide an ultra-stable 12 volts. A portion of the output is chopped by Q7 and Q8 operating with T2 at approximately 200 cps to provide at the secondaries of T2 plus 150 and minus 100 volts. These voltages are filtered by multisection filters and delivered to the amplifier.

I detail the regulator operates as follows:

Q5 and Q6 form an error amplifier which detects any difference between the voltage across Zener diode D4 and the divider R211 and R212. Any error signal which exists is applied to the series transistor Q1 via the intermediate amplifiers, Q2, Q3, and Q4 in such a way as to cancel the error signal. The gain is of such a magnitude around the loop and the speed of response is such that it is generally impossible to detect an output signal for any input voltage variation within the operating capability of the regulator.

The 117 volt winding is used to supply current to D5, a 10 volt Zener diode, which supplies the collector voltage for driver transistor Q4. A regulated voltage at this point makes an important contribution to the stability of the power supply.

T2 and Q7 and Q8 form a familiar type of transistor power converter. The winding between the collectors is driven into saturation first by one transistor than by the other. A feedback winding to the transistor bases maintains oscillation. The frequency of oscillation is determined by the core inductance.

SECTION V - MAINTENANCE

A. GENERAL:

The amplifier itself requires no maintenance. Since the input tubes are matched and selected, tube change should be avoided unless absolutely necessary. If the amplifier is used with batteries the usual maintenance necessary for batteries must be adhered to. If the power supply is used, it should require no maintenance.

B. TROUBLE SHOOTING:

If the amplifier does not operate be certain that the batteries have not run down or that the power supply is at fault. Since the circuit of the amplifier is extremely simple, if the trouble is in the amplifier, following the voltage resistance diagram should locate the trouble quickly.

If the power supply is at fault, a more detailed procedure should be followed.

Measure all voltages from the +12 bus. Check at the collector of Q1 for unregulated input voltage. If not present, check out filter components and transformer, if present, measure emitter voltage of Q1. If the 12 volts is present, check the plus 135 and minus 90 volts supplies, referring the ground of the voltmeter to the amplifier chassis.

If the 12 volts is not present, disconnect the converter by lifting one end of R213. If now the voltage goes to 12 volts, probably either Q7 or Q8 is defective or there is short on one of the secondaries of T2. If this does not cure the 12 volt supply, check the voltages by means of the voltage resistance diagram and try replacing transistors until the fault is found.

If the 12 volts is present but one of the high voltages is not, check for operation of the converter or a defect in the secondary circuit of T2.

HOW TO ORDER PARTS

Order component parts directly from the manufacturer or from Keithley Instruments, Inc. Order all structural parts from Keithley.

The Replaceable Parts List gives the code number of the component's manufacturer in the MFG. CODE column. The name and address of the manufacturer having the code number is listed in the Manufacturers' Code Definitions Table immediately following the Replaceable Parts List. When ordering from the manufacturer, purchase only quality components meeting the listed specifications.

When ordering from Keithley Instruments, give a description of the part being ordered, the circuit designation, the Keithley part number, the instrument model number, and the instrument serial number. Send to:

Order Service Department
Keithley Instruments, Inc.
12415 Euclid Avenue
Cleveland 6, Ohio

LIST OF SYMBOLS AND ABBREVIATIONS

a	Amperes	Ω	Ohm
Cer	Ceramic Disc	p	Pica (10^{-12})
CerV	Ceramic Variable	PST	Polystyrene Tubular
Comp	Composition		
CompV	Composition Variable	R	Resistor
DCb	Deposited Carbon	Sw	Switch
EC	Electrolytic Can	μ	Micro (10^{-6})
ETB	Electrolytic Tubular	V	Volts
f	Farad	Var	Variable
K	Kilo (10^3)	w	Watt
		WW	Wire Wound
m	Milli (10^{-3})	WWVar	Wire Wound Variable
M	Mega (10^6)		
My	Mylar		

MANUFACTURERS' CODE DEFINITIONS

00327	Welwyn International, Inc. Cleveland, Ohio	59289	Sprague Electric Co. North Adams, Mass.
00656	Aerovox Corp. New Bedford, Mass.	63743	Ward Leonard Electric Co. Mount Vernon, N. Y.
01121	Allen-Bradley Co. Milwaukee, Wisc.	71450	CTS Corp. Elkhart, Ind.
01295	Texas Instruments, Inc. Transistor Products Div. Dallas, Texas	71468	Cannon Electric Co. Los Angeles, Calif.
01661	Wilrite Products, Inc. Cleveland, Ohio	72928	Gudeman Co. Chicago, Ill.
02660	Amphenol Connector Div. of Amphenol-Borg Electronics Corp. Chicago, Illinois	72982	Erie Resistor Corp. Erie, Pa.
02735	RCA Semiconductor Div. of Radio Corporation of America Somerville, N. J.	73445	Amperex Electronic Co. Div. of North American Philips Co., Inc. Hicksville, N. Y.
08806	General Electric Co. Miniature Lamp Dept. Cleveland, Ohio	75915	Littlefuse, Inc. Des Plaines, Ill.
13065	Transitron Electron Corp. East Boston, Mass.	79727	Continental-Wirt Electronics Corp. Philadelphia, Pa.
12672	RCA Electron Tube Div. of Radio Corporation of America Woodridge, N. J.	80164	Keithley Instruments, Inc. Cleveland, Ohio
14655	Cornell-Dubilier Electric Corp. Newark, N. J.	80211	Motorola, Inc. Chicago, Ill.
15909	Daven Co. Livingston, N. J.	84411	Good-All Electric Mfg. Co. Ogallala, Nebr.
19701	Electra Mfg. Co. Kansas City, Mo.	91737	Gremar Mfg. Co., Inc. Wakefield, Mass.
37942	Mallory, P. R., and Co., Inc. Indianapolis, Ind.	95333	Central Transformer Co., Inc. Chicago, Ill.
44655	Ohmite Mfg. Co. Skokie, Ill.	99942	Hoffman Electronics Corp. Semiconductor Division El Monte, Calif.

REPLACEABLE PARTS LIST - MODEL 103

CAPACITORS

Circuit Desig.	Value	Rating	Type	Mfg. Code	Keithley Part No.
C101	1 μ f	200V	My	72928	C66-1.0
C102	1 μ f	200V	My	72928	C66-1.0
C103	1 μ f	200V	My	72928	C66-1.0
C105	.33 μ f	200V	My	00656	C29-.33
C106	.02 μ f	600V	Cer	14655	C22-.02
C107	.002 μ f	600V	Cer	72982	C22-.002
C108	330 pf	600V	Cer	72982	C22-330
C109	330 pf	600V	Cer	72982	C22-330
C110	.002 μ f	600V	Cer	72982	C22-.002
C111	.02 μ f	600V	Cer	14655	C22-.02
C112	.33 μ f	200V	My	00656	C29-.33
C113	22 pf	1000V	Cer	59289	C72-22P
C114	1.5/7 pf	500V	CerV	72982	C28-1.5/7
C115	1.5/7 pf	500V	CerV	72982	C28-1.5/7
C116	22 pf	600V	Cer	59289	C72-22
C118	40 μ f	250V	ETB	59289	C27-40
C119	40 μ f	250V	ETB	59289	C27-40
C121	330 pf	600V	Cer	72982	C22-330
C122	100 pf	600V	Cer	19701	C22-100
C123	33 pf	600V	Cer	72982	C22-33
C124	40 μ f	250V	ETB	14655	C27-40
C125	.01 μ f	600V	Cer	01121	C22-.01
C126	.003 μ f	600V	Cer	72982	C22-.003
C127	.001 μ f	600V	Cer	72982	C22-.001
C128	3/12 pf	500V	CerV	72982	C28-3/12
C130	40 μ f	250V	ETB	59289	C27-40

RESISTORS

Circuit Desig.	Value	Rating	Type	Mfg. Code	Keithley Part No.
R101	10 M Ω	10%, $\frac{1}{2}$ w	Comp	01121	R1-10M
R102	10 M Ω	10%, $\frac{1}{2}$ w	Comp	01121	R1-10M
R103	50 K Ω	1%, $\frac{1}{2}$ w	WW	15909	R55-50K
R104	500 K Ω	1%, $\frac{1}{2}$ w	DCb	00327	R12-500K
R105	50 K Ω	1%, $\frac{1}{2}$ w	DCb	01661	R12-50K
R106	500 K Ω	20%, $\frac{1}{2}$ w	CompV	71450	RP16-500K
R107	50 K Ω	1%, $\frac{1}{2}$ w	DCb	01661	R12-50K
R108	250 K Ω	1%, $\frac{1}{2}$ w	DCb	00327	R12-250K
R109	50 K Ω	1%, $\frac{1}{2}$ w	WW	15909	R55-50K
R110	50 K Ω	1%, $\frac{1}{2}$ w	WW	15909	R55-50K

REPLACEABLE PARTS LIST - MODEL 103

Resistors (cont'd)

Circuit Desig.	Value	Rating	Type	Mfg. Code	Keithley Part No.
R111	500 K Ω	1%, $\frac{1}{2}$ W	DCb	00327	R12-500K
R112	4.45 M Ω	1%, $\frac{1}{2}$ W	DCb	01661	R12-4.45M
R113	4.45 M Ω	1%, $\frac{1}{2}$ W	DCb	01661	R12-4.45M
R114	500 K Ω	1%, $\frac{1}{2}$ W	DCb	00327	R12-500K
R115	100 Ω	10%, $\frac{1}{2}$ W	Comp	44655	R1-100
R116	10 K Ω	10%, 2 W	WWVar	37942	RP3-10K
R117	10 K Ω	10%, $\frac{1}{2}$ W	Comp	01121	R1-10K
R118	50 K Ω	30%, $\frac{1}{2}$ W	CompV	71450	RP16-50K
R119	10 K Ω	10%, $\frac{1}{2}$ W	Comp	01121	R1-10K
R120	15 K Ω	1%, $\frac{1}{2}$ W	DCb	00327	R12-15K
R121	100 Ω	10%, $\frac{1}{2}$ W	DCb	44655	R1-100
R122	100 K Ω	10%, $\frac{1}{2}$ W	Comp	44655	R1-100K
R123	75 K Ω	1%, $\frac{1}{2}$ W	DCb	01661	R12-75K
R124	75 K Ω	1%, $\frac{1}{2}$ W	DCb	01661	R12-75K
R125	100 Ω	10%, $\frac{1}{2}$ W	Comp	44655	R1-100
R126	100 Ω	10%, $\frac{1}{2}$ W	Comp	44655	R1-100
R127	1.2 M Ω	1%, $\frac{1}{2}$ W	DCb	00327	R12-1.2M
R128	1.5 M Ω	1%, $\frac{1}{2}$ W	DCb	01661	R12-1.5M
R129	1.2 M Ω	1%, $\frac{1}{2}$ W	DCb	00327	R12-1.2M
R130	1.5 M Ω	1%, $\frac{1}{2}$ W	DCb	01661	R12-1.5M
R131	100 K Ω	10%, $\frac{1}{2}$ W	Comp	44655	R1-100K
R132	100 K Ω	10%, $\frac{1}{2}$ W	Comp	44655	R1-100K
R133	100 K Ω	10%, $\frac{1}{2}$ W	Comp	44655	R1-100K
R134	470 K Ω	10%, $\frac{1}{2}$ W	Comp	01121	R1-470K
R135	33 K Ω	1%, $\frac{1}{2}$ W	WW	15909	RP5-33K
R136	1 K Ω	10%, $\frac{1}{2}$ W	Comp	44655	R1-1K
R137	1 K Ω	10%, $\frac{1}{2}$ W	Comp	44655	R1-1K

MISCELLANEOUS PARTS

Circuit Desig.	Description	Mfg. Code	Keithley Part No.
I1	Lamp, neon (Vendor No. NE2H)	08806	PL-14
J2	Receptacle, UHF, "OUTPUT" (Mates with Keithley CS-69, Amphenol 83-822)	91737	CS-64
J3	Receptacle, AN3102A-18-18	02600	CS-23
P1	Receptacle, XLR-3-32 "INPUT" (Mates with Keithley CS-72, Cannon XLR-3-11C)	71468	CS-71
S1	Switch, Rotary, 4-position, 2-section	80164	SW-126
S2	Switch, Rotary, 2-position, 2-section	80164	SW-125

REPLACEABLE PARTS LIST - MODEL 103

Resistors (cont'd)

Circuit Desig.	Value	Rating	Type	Mfg. Code	Keithley Part No.
R111	500 K Ω	1%, $\frac{1}{2}$ w	DCb	00327	R12-500K
R112	4.45 M Ω	1%, $\frac{1}{2}$ w	DCb	01661	R12-4.45M
R113	4.45 M Ω	1%, $\frac{1}{2}$ w	DCb	01661	R12-4.45M
R114	500 K Ω	1%, $\frac{1}{2}$ w	DCb	00327	R12-500K
R115	100 Ω	10%, $\frac{1}{2}$ w	Comp	44655	R1-100
R116	10 K Ω	10%, 2 w	WWVar	37942	RP3-10K
R117	10 K Ω	10%, $\frac{1}{2}$ w	Comp	01121	R1-10K
R118	50 K Ω	30%, $\frac{1}{2}$ w	CompV	71450	RP16-50K
R119	10 K Ω	10%, $\frac{1}{2}$ w	Comp	01121	R1-10K
R120	15 K Ω	1%, $\frac{1}{2}$ w	DCb	00327	R12-15K
R121	100 Ω	10%, $\frac{1}{2}$ w	DCb	44655	R1-100
R122	100 K Ω	10%, $\frac{1}{2}$ w	Comp	44655	R1-100K
R123	75 K Ω	1%, $\frac{1}{2}$ w	DCb	01661	R12-75K
R124	75 K Ω	1%, $\frac{1}{2}$ w	DCb	01661	R12-75K
R125	100 Ω	10%, $\frac{1}{2}$ w	Comp	44655	R1-100
R126	100 Ω	10%, $\frac{1}{2}$ w	Comp	44655	R1-100
R127	1.2 M Ω	1%, $\frac{1}{2}$ w	DCb	00327	R12-1.2M
R128	1.5 M Ω	1%, $\frac{1}{2}$ w	DCb	01661	R12-1.5M
R129	1.2 M Ω	1%, $\frac{1}{2}$ w	DCb	00327	R12-1.2M
R130	1.5 M Ω	1%, $\frac{1}{2}$ w	DCb	01661	R12-1.5M
R131	100 K Ω	10%, $\frac{1}{2}$ w	Comp	44655	R1-100K
R132	100 K Ω	10%, $\frac{1}{2}$ w	Comp	44655	R1-100K
R133	100 K Ω	10%, $\frac{1}{2}$ w	Comp	44655	R1-100K
R134	470 K Ω	10%, $\frac{1}{2}$ w	Comp	01121	R1-470K
R135	33 K Ω	1%, $\frac{1}{2}$ w	WW	15909	R55-33K
R136	1 K Ω	10%, $\frac{1}{2}$ w	Comp	44655	R1-1K
R137	1 K Ω	10%, $\frac{1}{2}$ w	Comp	44655	R1-1K

MISCELLANEOUS PARTS

Circuit Desig.	Description	Mfg. Code	Keithley Part No.
I1	Lamp, neon (Vendor No. NE2H)	08806	PL-14
J2	Receptacle, UHF, "OUTPUT" (Mates with Keithley CS-49, Amphenol 83-822)	91737	CS-64
J3	Receptacle, AN3102A-18-1S	02660	CS-23
P1	Receptacle, XLR-3-32 "INPUT" (Mates with Keithley CS-72, Cannon XLR-3-11C)	71468	CS-71
S1	Switch, Rotary, 4-position, 2-section	80164	SW-126
S2	Switch, Rotary, 2-position, 2-section	80164	SW-125

REPLACEABLE PARTS LIST - MODEL 103

Miscellaneous Parts (Cont'd)

Circuit Desig.	Description	Mfg. Code	Keithley Part No.
S3	Switch, Rotary, 7-position, 2-section	80164	SW-124
S4	Switch, Slide, TPDT	80163	SW-128
S5	Switch, Slide, SPST	79727	SW-45

VACUUM TUBES

Circuit Desig.	Tube No.	Mfg. Code	Keithley Part No. -
V1	7586	12672	EV-7586
V2	7586	12672	EV-7586
V3	7586	12672	EV-7586
V4	7586	12672	EV-7586
V5	EF86	73445	EV-EF86
V6	EF86	73445	EV-EF86
V7	12AU7	73445	EV-12AU7

REPLACEABLE PARTS LIST - MODEL 1031

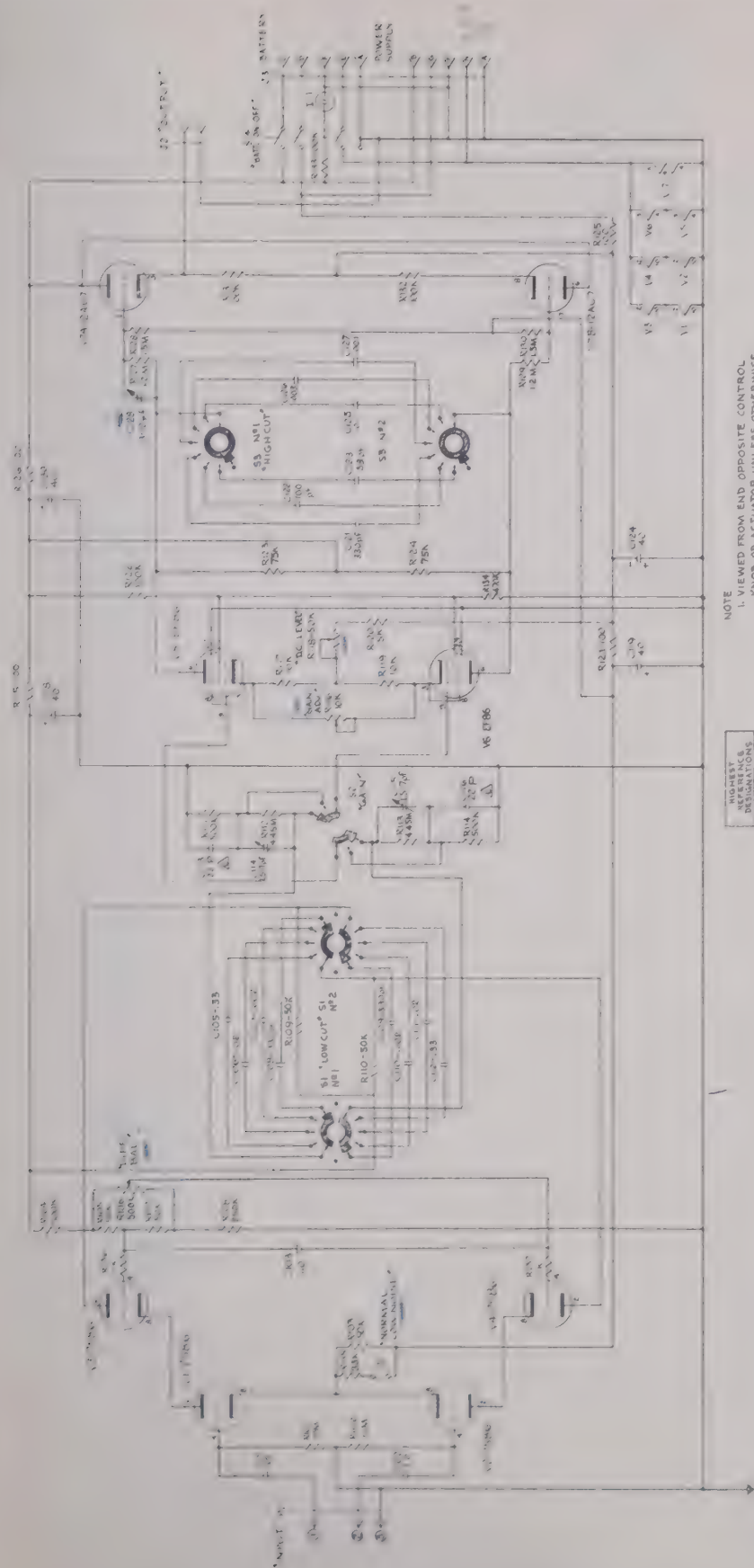
RESISTORS

Circuit Desig.	Value	Rating	Type	Mfg. Code	Keithley Part No.
R201	27 K Ω	10%, 1 w	Comp	01121	R2-27K
R202	3 Ω	10%, 10 w	WW	53743	R5-3
R203	560 Ω	10%, $\frac{1}{2}$ w	Comp	01121	R1-560
R204	10 K Ω	10%, $\frac{1}{2}$ w	Comp	01121	R1-10K
R205	10 K Ω	10%, $\frac{1}{2}$ w	Comp	01121	R1-10K
R206	680 Ω	10%, $\frac{1}{2}$ w	Comp	44655	R1-680
R207	10 K Ω	10%, $\frac{1}{2}$ w	Comp	01121	R1-10K
R208	4.7 K Ω	10%, $\frac{1}{2}$ w	Comp	01121	R1-4.7K
R209	500 Ω *	1%, $\frac{1}{2}$ w	DCb	00327	R12-500
R210	500 Ω *	1%, $\frac{1}{2}$ w	DCb	00327	R12-500
R211	10 Ω	10%, 10 w	WW	63743	R5-10
R212	150 Ω	10%, $\frac{1}{2}$ w	Comp	44655	R1-150
R213	2.2 K Ω	10%, $\frac{1}{2}$ w	Comp	01121	R1-2.2K
R214	100 Ω	10%, $\frac{1}{2}$ w	Comp	44655	R1-100
R215	100 Ω	10%, $\frac{1}{2}$ w	Comp	44655	R1-100
R216	100 Ω	10%, $\frac{1}{2}$ w	Comp	44655	R1-100
R217	100 Ω	10%, $\frac{1}{2}$ w	Comp	44655	R1-100
R218	100 Ω	10%, $\frac{1}{2}$ w	Comp	44655	R1-100
R219	100 Ω	10%, $\frac{1}{2}$ w	Comp	44655	R1-100
R220	100 Ω	10%, $\frac{1}{2}$ w	Comp	44655	R1-100
R221	100 K Ω	10%, $\frac{1}{2}$ w	Comp	44655	R1-100K
R222	10 Ω *	10%, 2 w	Comp	01121	R3-10

MISCELLANEOUS PARTS

Circuit Desig.	Description	Mfg. Code	Keithley Part No.
F1	Fuse .5 a/3 ag	75915	FU6
I1	Bulb, Neon (Vendor No. NE2H)	08806	PL14
J1	Receptacle, "OUTPUT", AN3102A-18-1S (Mates with Keithley CS-22, Amphenol AN3106A-18-1P)	02660	CS-23
S1	Switch, Toggle, SPST	79727	SW4
T1	Transformer, Power (Vendor No. K1-187)	95333	TR45
T2	Transformer, Switching (Vendor No. K1-185)	95333	TR44
	Cable Assembly between 103 and 1031 Connectors on each end, AN3106A-18-1P		14509B CS-22

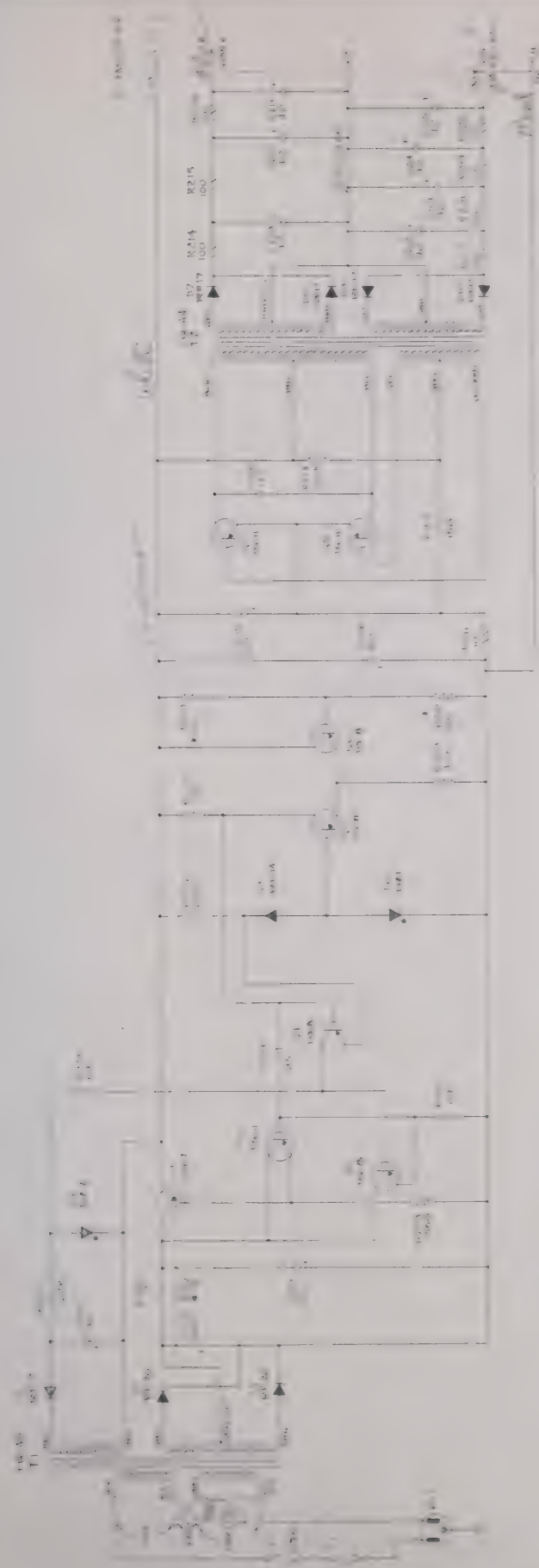
*Nominal value, set at manufacture



NOTE

1. VIEWED FROM END OPPOSITE CONTROL KNOB OR ACTUATOR UNLESS OTHERWISE INDICATED
2. TUBES TO BE MATCHED PER SPEC. MI-A-07
3. UNLESS OTHERWISE SPECIFIED ALL CAPACITORS IN MFD'S AND ALL RESISTANCES IN OHMS

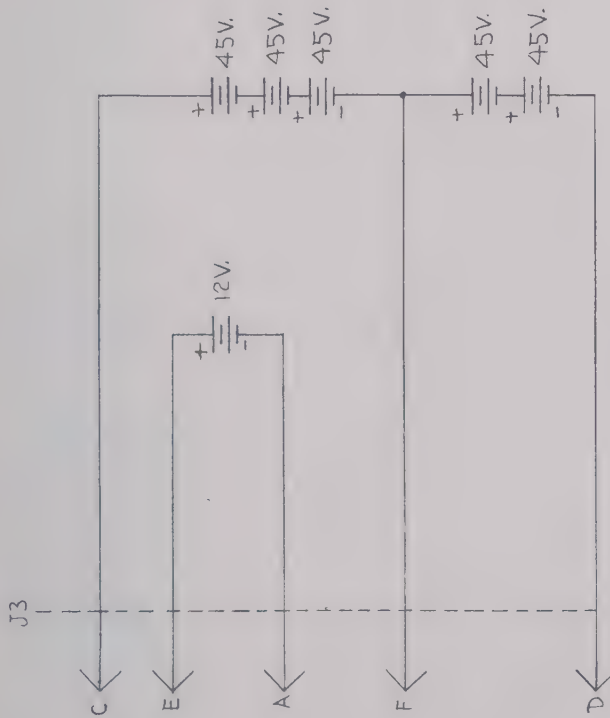
HIGHEST REFERENCE DESIGNATIONS	2 37 CISO	REFERENCE DESIGNATIONS NOT USED



HIGHEST REFERENCE IDENTIFICATION		
10	10	10
11	11	11
12	12	12
13	13	13
14	14	14
15	15	15
16	16	16
17	17	17
18	18	18
19	19	19
20	20	20

FIGURE 1. ASSEMBLY INSTRUCTIONS, NOMINAL VALUE
 AND AT FAILURE AND CAPACITANCE
 SHALL BE IDENTIFIED IN CIRCUIT AND
 IDENTIFICATION SHALL BE IDENTIFIED, UNLESS
 OTHERWISE NOTED

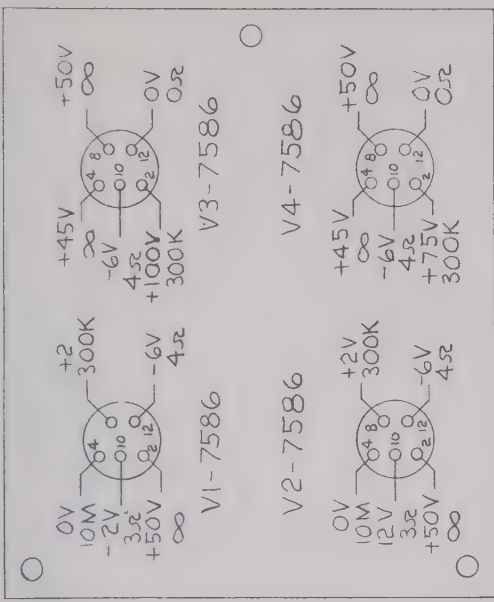
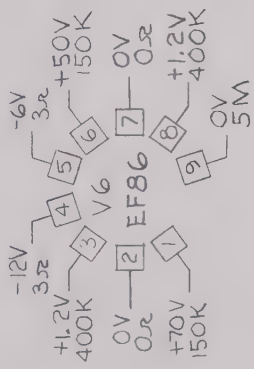
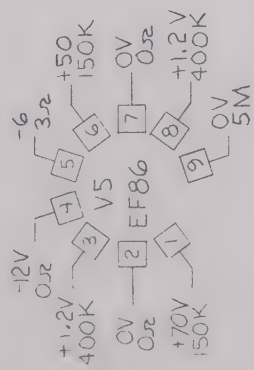
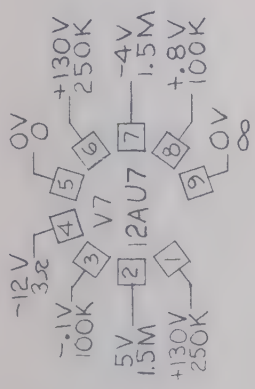
ITEM	DESCRIPTION	QUANTITY	REMARKS
1	TRANSFORMER	1	
2	DIODES	7	
3	RESISTORS	15	
4	CAPACITORS	5	
5	IC1 (7805)	1	
6	IC2 (7809)	1	
7	IC3 (LM311)	1	
8	IC4 (LM311)	1	
9	RELAY	1	
10	MOTOR	1	



REVISIONS		
SYM	DESCRIPTION	DATE
A	PILOT RUN <i>7-12-61</i> APPR.	
B	PRODUCTION <i>7-23-61</i> APPR.	

MATERIAL		FINISH		TITLE		KEITHLEY INSTRUMENTS, INC. CLEVELAND, OHIO	
DIMENSIONAL TOLERANCES UNLESS OTHERWISE SPECIFIED		BATTERY POWER SUPPLY SCHEMATIC		DRAWN RTF		DATE 7-12-61	
FRAC.	DEC.	ANG.		CHECKED gm	DATE 7-18-61	17-12	
± 1/64	± .005	± 30°		APPROVED K. H. J.	DATE 7-15-61		
SCALE	NO. REQ'D						
10:3	14485D						
MODEL	14485M						
	B/M						
	NEXT ASSEM.						
	USED ON						

REVISIONS		
SYM	DESCRIPTION	DATE
A	PILOT RUN	7-23-61
B	PRODUCTION	8-23-61



MODEL 103 VOLTAGE AND RESISTANCE CHART

ALL VOLTAGES TAKEN WITH REFERENCE AT GROUND.
 ALL READINGS TAKEN WITH H.P. 410B VTVM.
 READINGS TAKEN WITH POWER SUPPLY CONNECTED.
 GAIN SWITCH IN 1000 X POSITION.

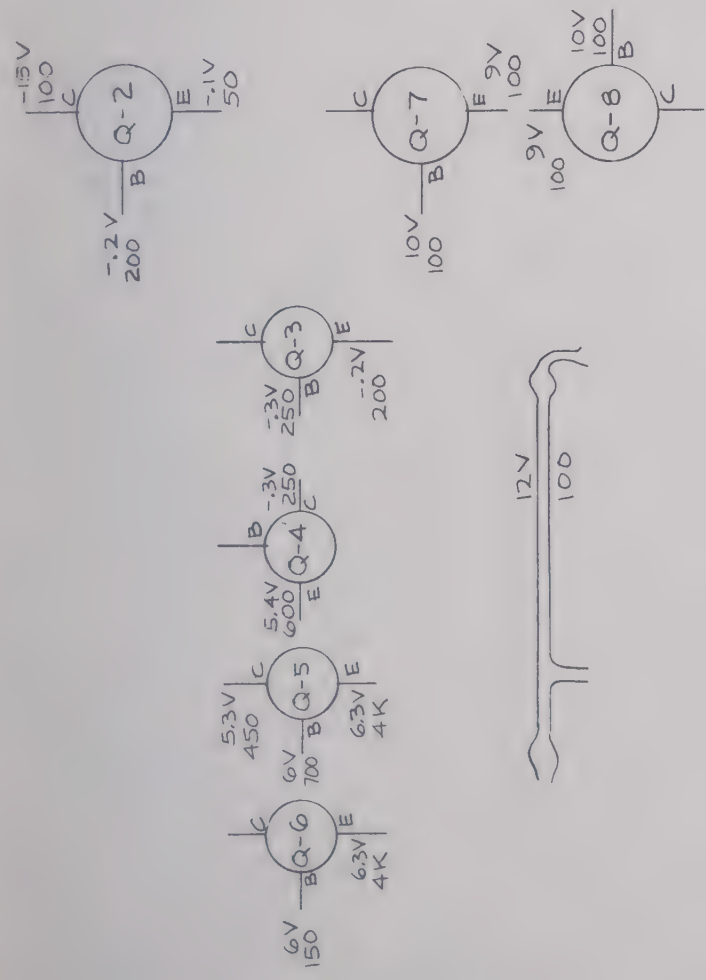
B/M 14485M

MATERIAL			FINISH	
DIMENSIONAL TOLERANCES UNLESS OTHERWISE SPECIFIED			TITLE	
FRAC.	DEC	ANG.	VOLTAGE AND RESISTANCE CHART	
± 1/64	± .005	± 30'		
SCALE	NO.	REQD	DRAWN	DATE
NTS			R.T.T.	7/26/61
NEXT ASSY			CHECKED	DATE
			APPROVED	DATE
			B.M.P.	7-17-61
			DRAWING NUMBER	
			14463B	
KEITHLEY INSTRUMENTS, INC. CLEVELAND, OHIO				

REVISIONS		
SYM	DESCRIPTION	DATE
A	PILOT RUN 100-5-22-61	
	APPR.	

PRODUCTION _____ APPR. _____

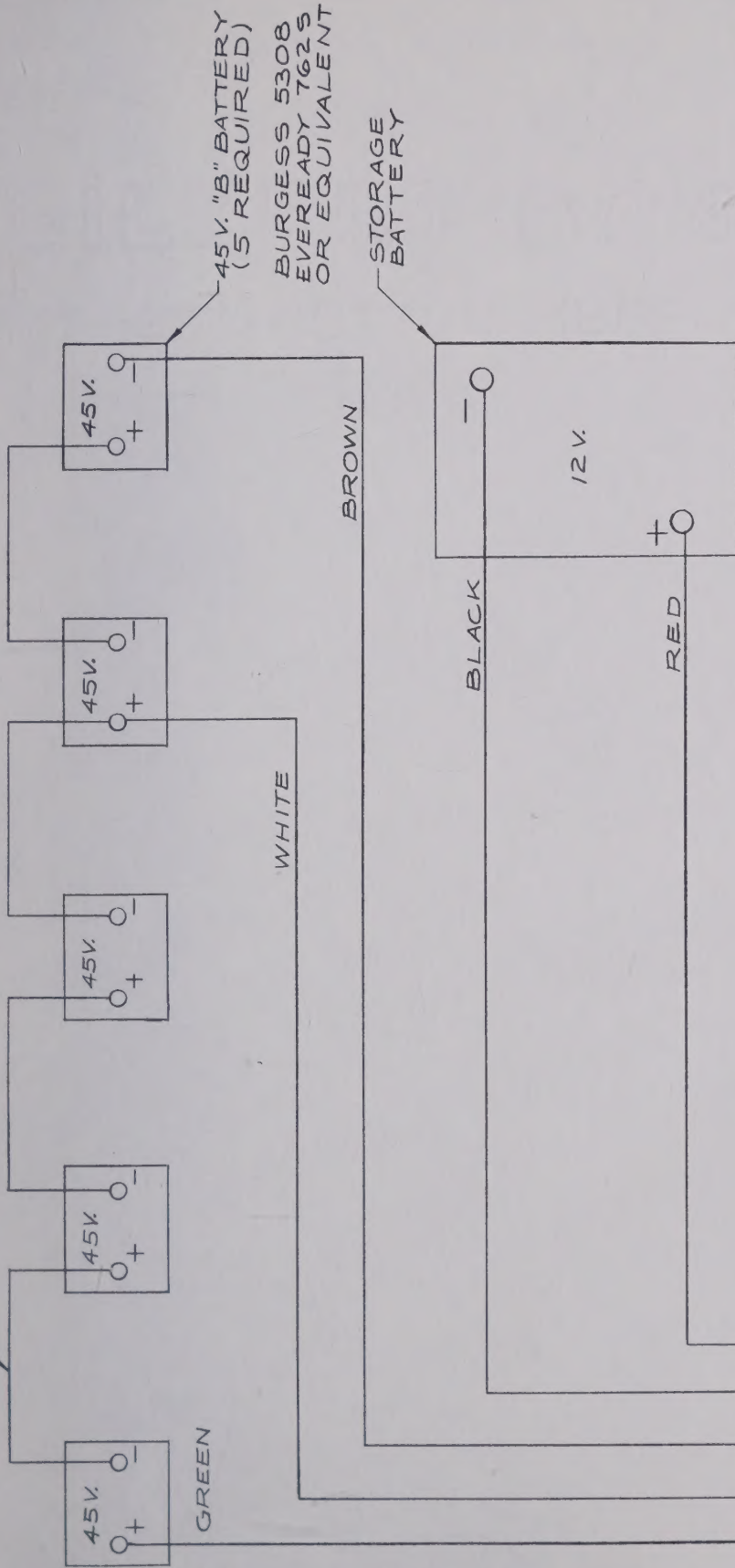
NOTE:
 1. ALL READINGS TAKEN WITH
 -12 VOLTS AS REFERENCE.
 2. RESISTANCE READINGS
 TAKEN WITH "HEWLETT-PACKARD
 MODEL 410B, R X 100 SCALE



TAPE SIDE SHOWN

MATERIAL		FINISH	
DIMENSIONAL TOLERANCES UNLESS OTHERWISE SPECIFIED		TITLE	
FRACTION	DECIMAL	ANG.	
± 1/64	± .005	± 30°	
SCALE	NTS	NO. REQD	
1031	14460M	144603	
MODEL	B M	NEXT ASSEM.	
USED IN		DRAWING NUMBER	
		14439B	
		KEITHLEY INSTRUMENTS, INC. CLEVELAND, OHIO	
		DATE 7-12-61	
		DATE 7-12-61	
		DATE 7-12-61	

14514B JUMPER ASSEMBLY
(4 REQUIRED)



REVISIONS		
SYM	DESCRIPTION	DATE
A	PRODUCTION ~~2-24-61~~ APPR. 8-30-61	

MATERIAL		FINISH	
DIMENSIONAL TOLERANCES UNLESS OTHERWISE SPECIFIED		TITLE	
FRA.	DEC.	ANG.	WIRING DIAGRAM, BATTERY POWER SUPPLY
± 1/64	± .005	± 30°	
SCALE	NTS	NO REQ'D	DRAWN <i>cm</i>
NEXT ASST.			CHECKED <i>cm</i>
USED ON		DATE 8-30-61	DRAWING NUMBER
MODEL	B/M	DATE 8-30-61	14610B
103	14485M		
14485M	14485M		
		KEITHLEY INSTRUMENTS, INC. CLEVELAND, OHIO	



KEITHLEY INSTRUMENTS, INC.
12415 EUCLID AVENUE CLEVELAND 6, OHIO